NHB 5300.4(3A)
(Formerly NPC 200-4)
MAY 1968
EDITION

RELIABILITY AND QUALITY ASSURANCE PUBLICATION

REQUIREMENTS FOR SOLDERED ELECTRICAL CONNECTIONS

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

PREFACE

Date: May 1968

In order to maintain the high standards of the NASA soldering programs, this publication:

1. Prescribes NASA's requirements for hand and machine soldering for reliable electrical connections.

2. Establishes the supplier's responsibility to train and certify personnel.

3. Provides for supplier documentation of those fabrication and inspection procedures to be used for NASA work, including supplier innovations and changes in technology.

APPLICABILITY

NASA Installations shall:

1. Invoke the provisions of this publication in procurements involving solder connections for aircraft, spacecraft, launch vehicles and mission essential support equipment, and elements thereof as appropriate to design or project needs.

2. Amend, when timely and within cost constraints, existing contracts to invoke the requirements of this publication.

3. Utilize the provisions of this publication for in-house soldering operations and, as necessary, for training and certification of in-house personnel.

4. Furnish copies of this publication in the quantities required to NASA contractors, subcontractors and subtier suppliers.

NASA contractors shall invoke the requirements of this publication in subcontracts and purchase orders.

Questions concerning application of this publication to specific procurements shall be referred to the procuring NASA installation or its designated representative.

This publication shall not be rewritten or reissued in any other form.

Copies of this publication are available from the Superintendent of Documents U.S. Government Printing Office, Washington, D.C. 20402.

SUPERSEDED DOCUMENTS

The following are hereby superseded:

1. Quality Requirements for Hand Soldering of Electrical Connections (NPC 200-4). Detailed soldering guidelines formerly covered by NPC 200-4 are published in the Fourth Edition of SP-5002 "Soldering Electrical Connections."

2. NMI 5330.3.

3. NMI 5330.4A.

Any NASA (including NASA installation) document, publication, regulation, etc., inconsistent with the provisions of this NHB 5300.4(3A) is hereby superseded. Also, NASA field installations will comply with the requirements of par. 4b of NPD 1410.1A in this regard.

John E. Condon

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Director
Reliability and Quality
Assurance

DISTRIBUTION:
SDL I (SIQ)

ORGANIZATION OF THE R&QA MANUAL

OVERALL COVERAGE

The Reliability and Quality Assurance Manual--referred to as the "R&QA Manual"--is the overall generic title which identifies all NASA R&QA management publications published under the basic R&QA subject classification code. The publications are grouped by major subject breakdown and further divided into specific categories identified as Parts. These Parts (not a complete R&QA Manual) are published as individual R&QA publications.

The following list shows the grouping and initial plan for publishing the individual R&QA publications:

Part	Title	Assigned no.
	Volume I - General Provisions	
A	Reliability Program Requirements	_____
B	Quality Program Requirements	_____
	Volume 2 - Government Agency Provisions	
A	Management of Government Quality Assurance Functions for Supplier Operations	_____
B	Quality Assurance Requirements	_____
	Volume 3 - Standards	
A	Requirements for Soldered Electrical Connections (Formerly NPC 200-4)	NHB 5300.4(3A)

DOCUMENT REFERENCING

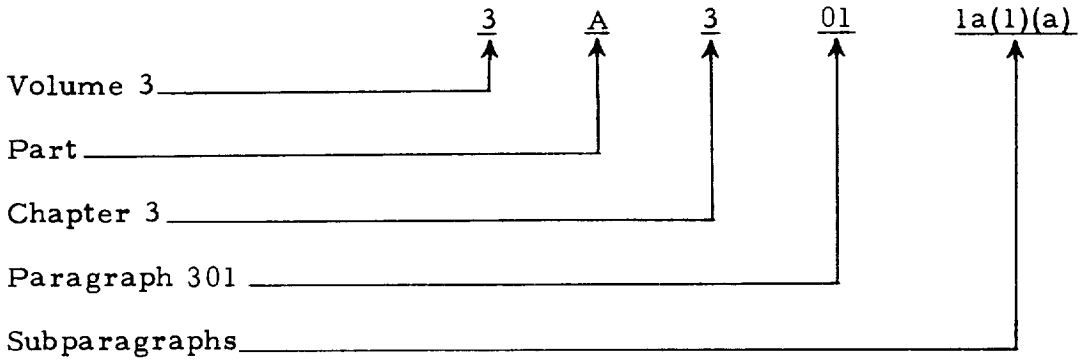
Each R&QA Manual Part is assigned its own identification number within the basic classification code. The numeric-alpha suffix within a parenthesis identifies the grouping of the publication, that is, the volume and part, such as NHB 5300.4(3A): this number indicates that this is the first "Standards" (Volume 3) publication to be issued.

When a part is revised, the suffix identification will be changed to indicate the revision number such as NHB 5300.4(3A-1).

In referencing or requesting any R&QA publication, the complete specific NHB number must be used.

PARAGRAPH REFERENCING

1. Within the R&QA Manual. The following shows the paragraph numbering system applicable to all R&QA publications.



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2. In Other NASA Documents. When it is necessary to reference an R&QA publication requirement (paragraph) in any other NASA document, the specific NHB number and paragraph number must be used together as follows: "NHB 5300.4(3A), par. 3A301-1a(1)(a)," or "paragraph 3A301-2b of NHB 5300.4(3A)."

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CHAPTER 1: BASIC PRINCIPLES

3A100 SCOPE

1. This publication sets forth hand and machine soldering requirements for reliable electrical or electronic connections. For the purposes of this document, the definitions in Appendix A shall apply.

2. This publication does not include specific requirements or specifications for the subjects listed below; however, these subjects are discussed in the paragraphs indicated as they relate to the requirements of this document. Contracts and purchases citing this publication shall contain detailed requirements to cover these items where applicable, including provisions for materials and applications suited to the intended use and environment.

   Special storage and handling (par. 3A307)

   Wire insulations, sleeving (par. 3A308, 3A610)

   Ultrasonic cleaning (par. 3A311)

   Terminals (par. 3A312)

   Special parts mounting requirements (par. 3A500)

   Potting compounds (par. 3A504)

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   Integrated circuits (par. 3A505)

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   Printed wiring (par. 3A800)

   Conformal coating (par. 3A800)

   Magnification (par. 3A703, 3A805, 3A905)

   Clean room requirements

3A101 GENERAL

1. NASA quality assurance personnel will advise and assist contractors, suppliers, NASA personnel and delegated agencies in the proper and effective implementation of the provisions of this document.

2. Where related requirements or changes in requirements are required, NASA quality assurance personnel will insure that the Government agency delegated to inspect at the supplier's site of fabrication has received full instructions so that the work will be inspected to the actual contract requirements.

3. Unless parts are fabricated specifically to comply with contracts or subcontracts citing this publication, internal connections of parts (as parts are defined in Appendix A) are not subject to the requirements of this publication. The supplier should assure himself that parts have suitable internal connections which will not unsolder or deteriorate when external connections are made by his processes.

3A102 RELATED DOCUMENTS

1. APPLICABLE SPECIFICATIONS. Copies of the following applicable specifications required in connection with a specific procurement may be obtained from the procuring NASA Installation or as directed by the contracting officer:

   QQ-S-571 - Solder, Tin Alloy; Lead Tin Alloy; and Lead Alloy.

   MIL-F-14256 - Flux, Soldering, Liquid (Rosin Base).

   Unless otherwise specified, the issue in effect on the date of invitation for bids or request for proposal shall apply.

2. REFERENCE PUBLICATION. The Fourth Edition, NASA SP-5002 "Soldering Electrical Connections," contains many detailed suggestions and techniques on how to satisfy the requirements of this publication. SP-5002 is available for purchase at 30¢ per copy from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402. NASA personnel should order copies through their installation technical library.

3A103 DEVIATION AND WAIVER REQUESTS

This publication requires:

1. Written approval of the cognizant NASA contracting officer or his designated NASA representative, for technical changes, deviations or waivers.

2. All deviation and waiver requests shall be supported by objective evidence and data substantiating that quality will not be compromised.

3A104 REWORK

Rework, as defined in Appendix A, is permissable unless excluded by other provisions of the contract. All rework shall meet the requirements of this publication. Rework is not repair. Repair shall be made only in compliance with applicable contractual requirements.

CHAPTER 2: SUPPLIER SOLDERING PROGRAM

3A200 GENERAL

The supplier is responsible for maintaining a documented soldering program which meets the requirements of this publication for the types of solder connections utilized in the articles involved. Portions of this publication, including illustrations, may be abstracted for the program.

3A201 TRAINING AND CERTIFICATION

The supplier is responsible for:

1. Providing necessary training of his personnel in the use of equipment employed and for insuring that all personnel who perform or inspect soldering are adequately skilled to fabricate the types of soldered connections required.

2. Certifying all personnel who perform or inspect soldering as being currently qualified to fulfill all requirements of this publication pertaining to the types of connections to be soldered. Records or evidence of certification status shall be maintained in the work area.

3. Maintaining appropriate records of training, including the certification criteria for each individual's latest certification.

3A202 MAINTENANCE OF CERTIFIED STATUS

1. The procuring Installation or its designated representative, or the supplier's instructor, may require supplier soldering personnel to demonstrate proficient workmanship on applicable hardware, or to be recertified.

2. The procuring Installation or its designated representative or the supplier's instructor, may require supplier inspection personnel to demonstrate proficient inspection performance and knowledge on applicable hardware or to be recertified.

3A203 RECERTIFICATION

1. The need for recertification shall be based on observation of the unsatisfactory quality of articles fabricated, or interruption of work period for more than 30 days.

2. Recertification shall be required when:

   a. Proficiency requirements herein are not met.

   b. New techniques have been developed which require different skills.

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c. Certificate holder changes employment.

d. There is reason to question workmanship of operators or inspection performance by inspectors.

3. Procedures for recertification shall include sufficient training or retraining to enable the candidate to demonstrate proficiency in fabricating or inspecting the types of solder connections involved in his assigned work. A proficiency demonstration shall be required of each candidate.

3A204 REVOCATION OF CERTIFIED STATUS

Certifications shall be revoked for operators or inspectors when:

1. Certificate holder requires recertification according to paragraph 3A203 and fails to be recertified.

2. Supplier training program fails to meet requirements as set forth herein or as set forth otherwise in the contract.

3. Certificate holder leaves employment.

4. Certificate holder fails to meet visual acuity requirements of paragraph 3A205.

3A205 VISION REQUIREMENTS

1. The supplier is responsible for ensuring that all personnel who perform soldering or inspect soldered connections meet the following vision test requirements as prerequisite to training and to certification and recertification. The vision requirements may be met with corrected vision (personal eye-glasses). The eye tests shall be administered by qualified personnel, using standard instruments and techniques. Results of the vision examination shall be maintained and available for review.

2. The following are the minimum vision requirements:

   a. Far vision. Snellen Chart 20/50.

   b. Near vision. Jaeger 1 at 14 inches; or reduced Snellen 20/20 or equivalent.

   c. Color vision. Ability to distinguish red, green, blue and yellow colors as prescribed in Dvorine Charts, Ishihara Plates, or AOD-HRR Tests. A practical test, using color coded wires and/or color coded electrical parts as applicable, will be acceptable for color vision testing.

3A206 WORKMANSHIP STANDARDS

The supplier shall:

1. Prepare visual standards consisting of satisfactory work samples or visual aids which clearly illustrate the quality characteristics for all soldered connections involved.

2. Utilize applicable illustrations in this publication, supplemented as necessary for visual standards.

3. For approved connections other than those illustrated herein, prepare appropriate visual standards.

4. Clearly illustrate by these standards preferred workmanship and the difference between acceptable and unacceptable workmanship.

5. Make applicable visual standards readily available to concerned personnel and use them in the training program.

6. Use these standards for inspection criteria and evaluation of personnel performance.

3A207 DOCUMENT SUBMITTAL

1. Documents required herein shall be submitted to the procuring NASA Installation or its designated representative for review. Applicable supplier soldering program documents, or portions thereof, accepted on other NASA contracts shall be included to avoid duplication of effort.

2. The supplier shall describe the training and certification program he proposes to satisfy the requirements herein for the types of solder connections he will make. This description shall include the following, as applicable:

   a. Qualifications of instructors

   b. Procedures for training

   c. Lesson plan(s)

   d. Hours of instruction

   e. Procedures for certification and recertification.

3. The supplier shall document the fabrication and inspection procedures he proposes to satisfy the requirements of this publication.

CHAPTER 3: FACILITIES, EQUIPMENT AND MATERIALS

3A300 FACILITY CLEANLINESS

The supplier is responsible for maintaining soldering areas in a clean orderly condition. Smoking, eating and drinking at the work stations shall not be permitted.

3A301 ENVIRONMENTAL CONDITIONS

1. The soldering area shall have a controlled environment which limits entry of contamination. This area shall be continuously controlled as follows:

   Temperature ..... 75° ± 10° F
   Relative Humidity ..... Max. 60%

2. In field operations, and where soldering under controlled conditions is impractical, adequate precautions shall be taken to maintain the required quality of solder connections.

3A202 LIGHTING REQUIREMENTS

Light intensity shall be a minimum of 100 foot-candles on the work surface.

3A303 TOOL AND EQUIPMENT CONTROL

The supplier shall:

1. Select tools and equipment used in soldering, and in preparations thereto, for intended function.

2. Properly clean and maintain equipment and tools.

3. Document or reference, in the supplier's soldering program, detailed operating procedures and maintenance schedules for tools and equipment requiring calibration or set-up.

4. Maintain records of tool calibration and verification.

3A304 HEAT SOURCES

1. SUPPLIER RESPONSIBILITY. The supplier shall:

   a. Choose a means of applying heat to the metals to be joined that is compatible with the size, shape, and thermal conductivity of the work pieces.

   b. Provide in operating procedures for cleanliness of the heat source to ensure uniform heat transfer and prevent contamination of the solder connection.

   c. Forbid use of soldering guns.

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2. RESISTANCE-TYPE SOLDERING ELECTRODES. The surfaces of electrodes shall be kept free of dirt and corrosion.

3. CONDUCTION-TYPE IRONS. The tip shall be periodically checked for:

   a. Proper insertion.

   b. Tight attachment.

   c. Cleanliness.

   d. No oxidation scale between tip and heat element.

   e. Continuously tinned surface on the tip working surface to insure proper heat transfer and to prevent transfer of impurities.

4. NONCONTACT HEAT SOURCES. When soldering heat is applied by a jet of heated gasses, or by radiant energy beams, the supplier shall set up, operate, and maintain the equipment by established, documented procedures.

3A305 CONDUCTOR PREPARATION TOOLS

The supplier shall select and use conductor preparation tools as follows:

1. Select insulation strippers and lead bending tools which do not nick, ring, gouge or scrape conductors or damage parts.

2. Select part lead cleaning tools which do not damage leads and parts and which do not cause contamination and hinder solder wetting.

3. Use the correct size of stripping tools or machines and maintain them in calibration.

4. Verify, periodically, insulation strippers and lead bending tools for proper operation.

5. Remove defective or uncalibrated tools and strippers promptly from the work area.

3A306 THERMAL SHUNTS

Thermal shunts shall be utilized where heat from the soldering operation may degrade the quality of heat sensitive parts or of previously soldered connections.

3A307 IN-PROCESS STORAGE AND HANDLING

The supplier is responsible for proper storage and handling and providing means to prevent contamination of printed wiring termination areas, terminals, wire ends, or part leads during handling and storage. Containers compatible with materials stored are required. When handling of bare copper surfaces is unavoidable, white gloves or finger cots shall be used.

3A308 MATERIALS SELECTION

The supplier is responsible for selecting materials suitable for intended use which do not degrade the quality of the solder junction, and metals or parts being joined.

3A309 SOLDER

Solder shall conform to Federal Specification QQ-S-571, Type RA or RMA for cored solder; and type S, form B or I for solid solder, and shall be composition Sn60 - Sn63, unless otherwise required by a NASA-approved design.

3A310 FLUX

1. TYPES AND USAGE. The supplier's process documentation shall describe the types of fluxes, where each is used, and necessary precautions.

2. LIQUID ROSIN FLUX. Liquid rosin flux shall conform to MIL-F-14256, Type A, except that the copper mirror test (par. 3.5) is not required, and that the resistivity of water extract (par. 3.2.6) shall be at least 45,000 ohm-centimeters. Liquid flux used with flux-cored solder shall be chemically compatible with the solder core flux and with the materials with which it will come in contact.

3A311 SOLVENTS

1. Solvents and processes proposed by the supplier for cleaning and flux removal shall be submitted for review. Solvents shall be non-conductive, noncorrosive, and shall not dissolve or degrade the quality of parts or materials.

CAUTION!
Solvents shall not be used in any manner which will carry dissolved flux residue on to contact surfaces such as those in switches, potentiometers, or connectors.

2. The following solvents are acceptable when properly used for cleaning in soldering operations:

   a. Ethyl alcohol, ACS grade, 99.5% or 95% by volume.

   b. Isopropyl alcohol, best commercial grade, 99% pure.

   c. Trichlorotrifluoroethane, clear, 99.8% pure.

   d. Any mixtures of the above.

CAUTION!
Ultrasonic cleaning, if used, shall be employed with caution to prevent damage to parts.

3A312 TERMINALS

1. Solder terminals shall comply with the contractual specification or drawing.

2. Hot dipped, tin-lead coated terminals are preferred. Terminals with uneven or excessive coating on the mounting surfaces shall not be used as they may loosen in subsequent soldering operations.

3. Terminals shall be of proper size to accommodate the conductors. Terminals and conductors shall not be modified to accommodate improper sizes.

CHAPTER 4: PREPARATION FOR SOLDERING

3A400 PREPARATION OF CONDUCTORS

1. INSULATION REMOVAL. Stripping tools or machines used shall be of the correct size for the wire used and in current adjustment and/or calibration.
2. DAMAGE TO INSULATION. After insulation removal or stripping, wires shall be examined for damage such as crushing or charring. Wires with damaged insulation shall not be used. Slight discoloration from thermal stripping is acceptable.
3. DAMAGE TO CONDUCTORS. After stripping, wires shall be examined to insure that the strands have not been nicked, cut, scraped, or otherwise damaged. Damaged wires shall not be used.
4. WIRE LAY. The lay of the wire strands shall be restored if disturbed, without using bare finger contact.
5. CONDUCTORS. Conductors or part leads shall not be reduced in cross-sectional area. Part leads or solid wires shall be pretinned and shall be cleaned immediately prior to attaching. No solvent shall be permitted under the insulation. Flux shall be applied so that it does not go under the insulation except for traces carried up by solder wicking.
6. TINNING OF STRANDED CONDUCTORS. Stripped ends of stranded wires shall be tinned to prevent untwisting and separation of wire strands.
7. WICKING. Flow (wicking) of solder along the conductors is permitted but shall not obscure the wire contour at the termination end of the insulation.

3A401 PREPARATION OF TERMINALS AND SOLDER CUPS

Terminals shall be examined and cleaned when necessary immediately prior to attachment of conductors.

3A402 ADDITIONAL REQUIREMENTS

1. SOLID HOOKUP WIRE. Solid hookup wire shall not exceed a length of one inch between supports. For wires over one inch in length, attachment to a surface by conformal coating is adequate support.
2. STRESS RELIEF. Each conductor terminating at a connection point shall have an allowance for stress relief to minimize tensile or shear stress to the soldered connection or part during thermal expansion.
3. MECHANICAL SUPPORT. Wire bundles shall be supported so that the soldered connections are not subjected to mechanical loads.
4. SPLICES. Conductors shall not be spliced except as authorized by the procuring NASA Installation.

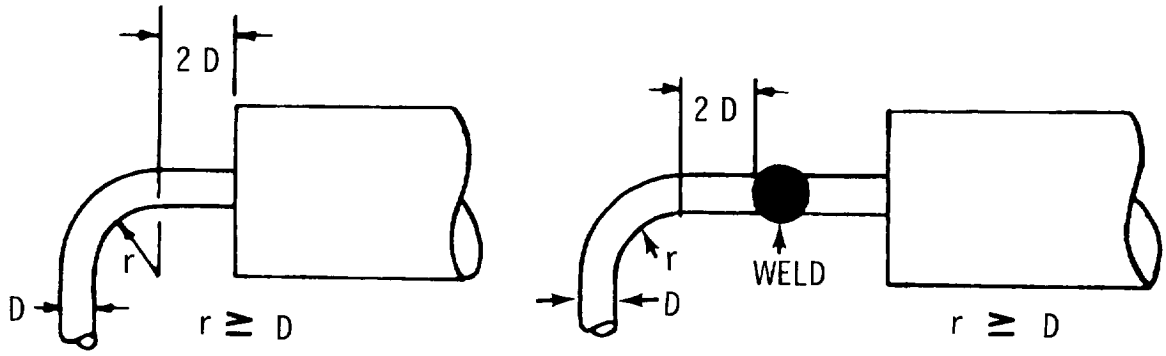
CHAPTER 5: PARTS MOUNTING

3A500 GENERAL REQUIREMENTS

1. Unless otherwise specified or approved by the procuring NASA Installation, parts shall be mounted parallel to, and in contact with the mounting surface.
2. IRREGULARLY SHAPED PARTS. When the shape of parts is such that only point contact can be made with the mounting surface, additional support shall be provided.
3. HEAVY PARTS. Parts which weigh more than 1/2 ounce (14 grams) shall be supported. Design requirements shall specify method of support or attachment.
4. METAL CASE PARTS. Metal cased parts mounted over printed conductors, or which can come in contact with each other or with other conductive material, shall be encased in transparent insulation. Such parts shall not be mounted over solder connections.
5. GLASS ENCASED PARTS. Glass encased parts (such as diodes) shall be enclosed in transparent resilient sleeving or coating material when epoxy material is used for support, conformal coating, or potting.

3A501 LEAD BENDING REQUIREMENTS

1. GENERAL. During bending or cutting, part leads shall be supported to minimize axial stress and avoid damage to seals or internal bonds. The inside radius of bend shall not be less than the lead diameter. The distance from the bend to the end seal shall be approximately equal at each end of the part. The minimum distance shall be two lead diameters. The direction of the bend shall not cause the marking on the mounted part to be obscured. Where the lead is welded (as on a tantalum capacitor) the minimum distance is measured from the weld. (See Figure 5-1).



(a) STANDARD LEAD (b) WELDED LEAD

FIGURE 5-1--MINIMUM LEAD BEND

2. NONBENDABLE LEADS. Leads which cannot be bent shall be cut so that when mounted, the leads protrude through the board from 1/32" to 3/32". The contour of the end of the conductor shall be discernible after soldering. (See Figure 5-2.)

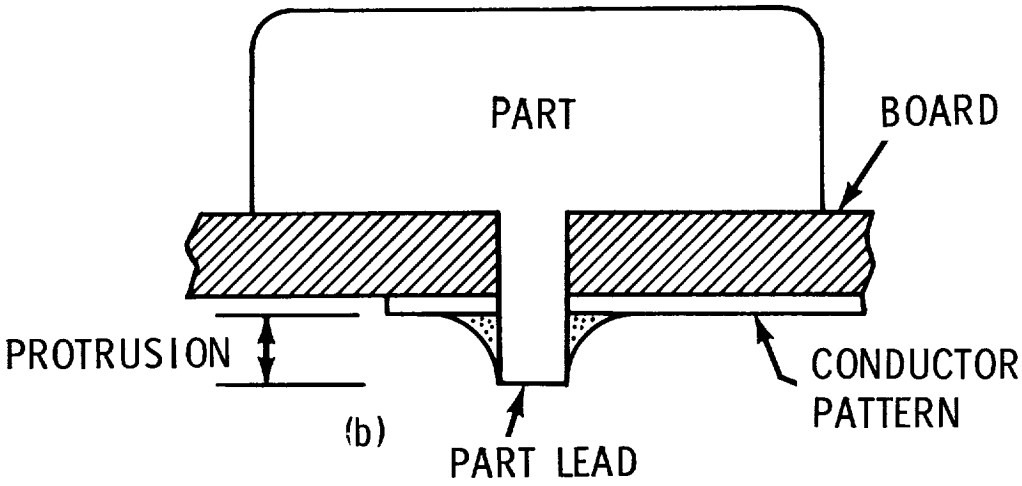


FIGURE 5-2--NONBENDABLE LEADS

3A502 LEAD CLINCHING, PRINTED WIRING BOARDS

1. GENERAL. The clinched lead shall not extend beyond the conductor pattern edge. The clinch shall not be forced to make the conductor lie flat at the bend radius. The innate springback of the part lead is acceptable. (See Figure 5-3.)

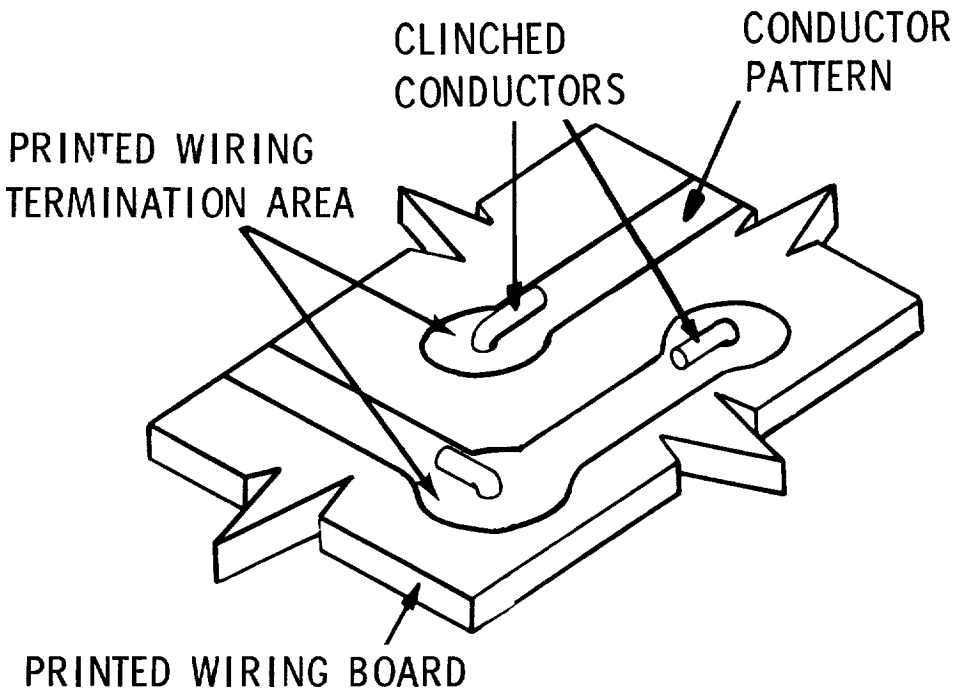


FIGURE 5-3--EXAMPLE OF CLINCH DIRECTION

2. ROUNDED TERMINATION AREAS. The leads shall extend through the board a minimum of the termination-area radius, and a maximum of two times the termination area radius, and shall be clinched in the direction of the conductor pattern.

3. IRREGULARLY SHAPED TERMINATION AREAS. For irregularly shaped termination areas, such as for shield and ground plane connections, the minimum clinch lead length shall be twice the diameter of the lead hole, and the maximum shall be four times the hole diameter.

3A503 MOUNTING OF PARTS TO TERMINALS

1. The length of leads between parts, and terminals shall be approximately equal at both ends, except when special part shapes, such as flanges on tophat diodes, requires staggering.

2. Each lead shall have provision for stress relief.

3. Degree of wrap, routing, and connection to terminals are specified in Chapters 6 and 7.

3A504 CORDWOOD MODULES

1. Parts in cordwood modules shall be mounted with the part axis perpendicular to the two parallel printed wiring boards.

2. Tubular parts shall be uniformly spaced between the printed wiring boards.

3. Coated parts shall be mounted so that coating on leads does not enter the mounting hole.

4. Termination of part leads shall be as specified herein, except when they are extended to serve as straight pin terminals (see paragraph 3A608), or as connections to the board on which the module is mounted.

5. Leads of heat sensitive parts shall not be used as straight pin terminals.

6. The selection and application of potting compound and the use of clinched or unclinched lead terminations shall be as approved by the procuring NASA Installation.

3A505 MOUNTING OF FLAT PACK CIRCUITS

1. The requirements of paragraph 3A502 shall not apply to the mounting of integrated circuit packages of the configuration known as "flat packs." Mounting may be on the wiring side of the boards, by lap solder joints to termination areas. Any bending of leads shall be done on suitable fixtures to prevent damage to seals.

2. Internal connections shall be suited to the intended use and environment and are not subject to the requirements of this publication.

CHAPTER 6: ATTACHMENT OF CONDUCTORS TO TERMINALS

3A600 GENERAL

1. Conductors shall be attached to terminals as illustrated in this section, which shows the requirements for routing to terminals, terminal fill, insulation clearance, and the extent of conductor wrap or bend.

2. For terminals not described or illustrated herein, similar procedures to accomplish the same intent shall be documented and submitted by the supplier for review by the procuring NASA Installation.

3A601 WIRE TERMINATION

1. BREAKOUTS FROM CABLES. For multiple wires routed from a common cable trunk to equally spaced terminals, the length of the wire ends, including vibration bend allowance shall be uniform to prevent stress concentration on any one wire.

2. MINIMUM INSULATION CLEARANCE. The insulation shall not be imbedded in the solder joint. The contour of the conductor shall not be obscured at the termination end of the insulation.

3. MAXIMUM INSULATION CLEARANCE. The maximum insulation clearance shall be less than two wire diameters including insulation but in no case shall permit shorting between adjacent conductors.

4. MULTIPLE PARALLEL ENTRY. For multiple parallel entry of wires to a terminal, insulation clearances need not be equal.

5. VARIATIONS. When characteristic impedance or circuit parameters are affected, such as in high voltage circuits or coaxial line terminations, the insulation clearance requirements may be modified. All variations shall be documented in the process procedures.

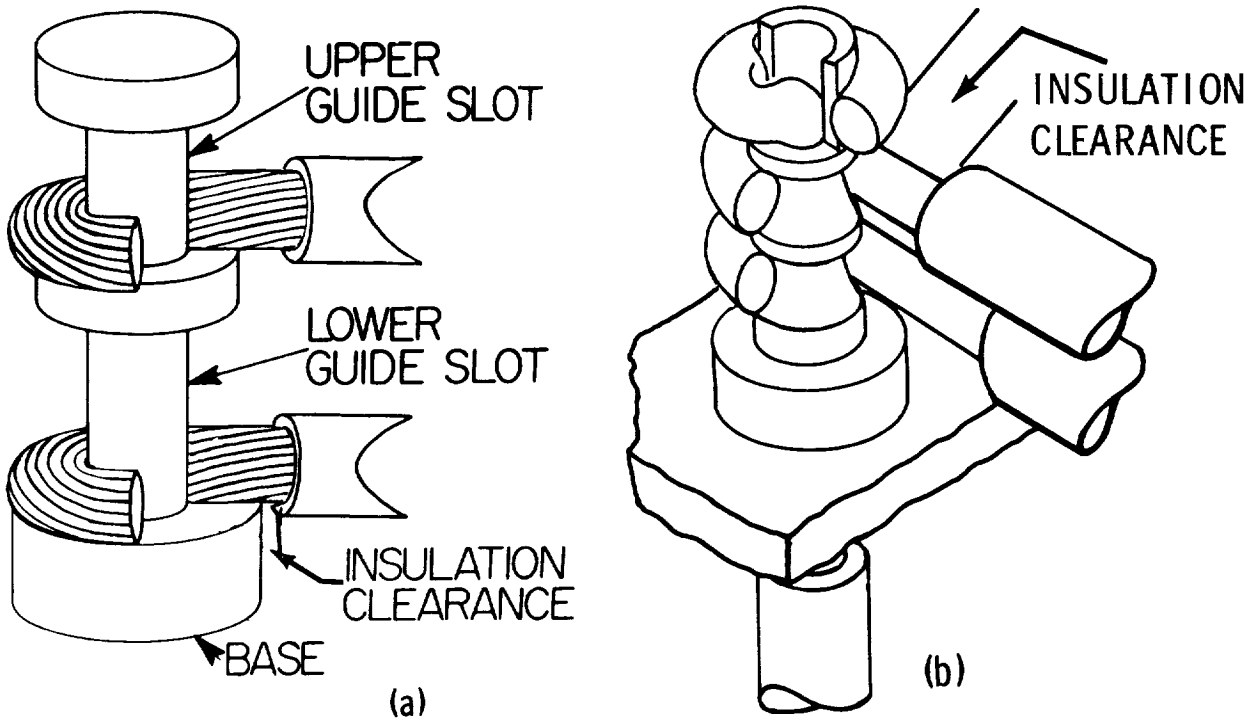


FIGURE 6-1--SIDE AND BOTTOM ROUTE CONNECTION TO TURRET TERMINALS

3A602 TURRET AND STRAIGHT PIN TERMINALS

1. SIDE ROUTE. The side route shall be connected as follows (see Figure 6-1 (a)):

   a. Conductor sizes AWG 26 and smaller shall be wrapped a minimum of 1/2 turn to a maximum of one full turn around the post.

   b. Conductor sizes larger than AWG 26 shall be wrapped a minimum of 1/2 to a maximum of 3/4 turn around the post.

   c. For turret terminals, all conductors shall be confined to the guide slots.

2. BOTTOM ROUTE. The conductor shall enter the terminal from the bottom, be brought through the side slot at the top, and wrapped as required for side route, see Figure 6-1 (b).

3A603 BIFURCATED TERMINALS

1. GENERAL. Top, side, or bottom routes, or combinations as illustrated in this chapter are permissable. Terminal side route connections shall not extend beyond the top of terminal.

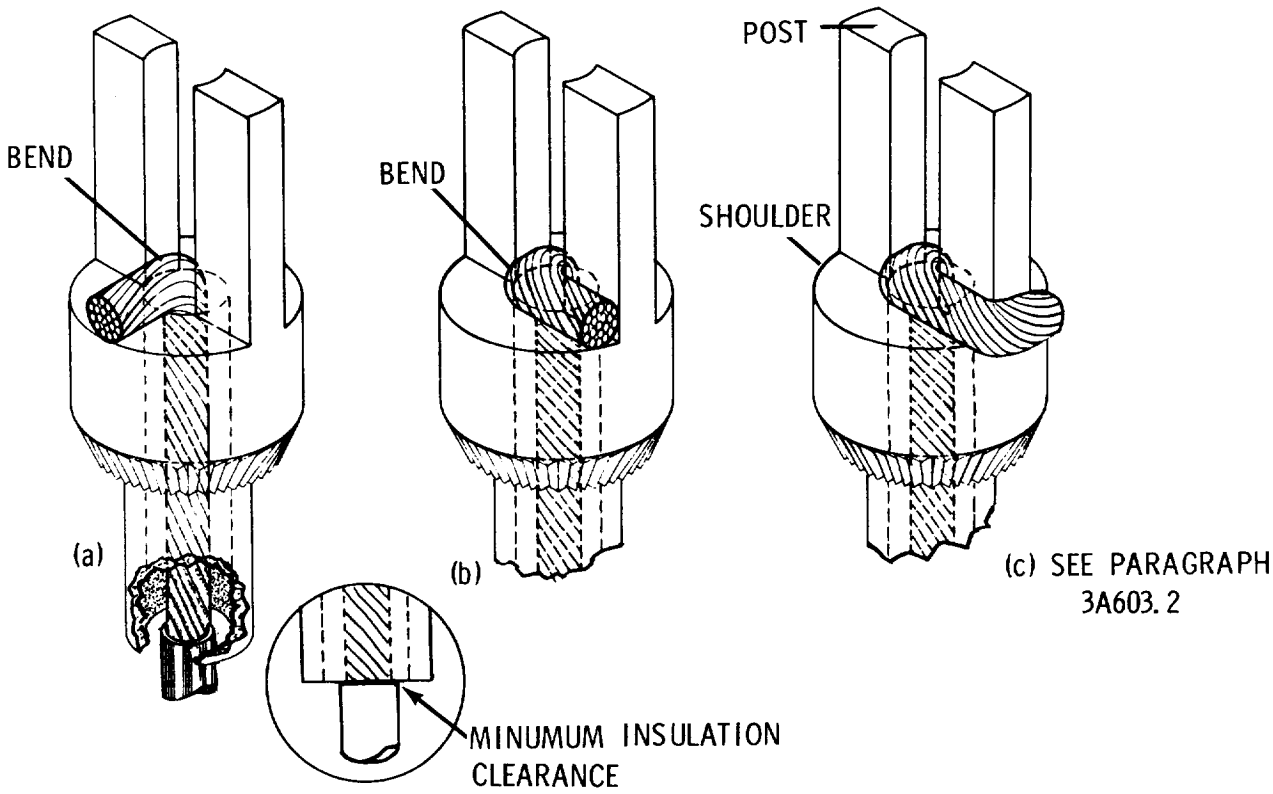


FIGURE 6-2--BOTTOM ROUTE CONNECTIONS TO BIFURCATED TERMINAL

2. BOTTOM ROUTE. Bottom route shall be connected as shown in Figure 6-2. Conductors shall not extend beyond the diameter of the base except as shown in Figure 6-2 (c), which is acceptable only when physical clearance is adequate for the intended environment and electrical characteristics.

3. SIDE ROUTE. Side route shall be connected as shown in Figure 6-3. The conductor shall enter the mounting slot perpendicular to the posts. When more than one conductor is connected to a terminal, the direction of bend of each additional conductor shall alternate. Conductors shall not extend beyond the diameter of the base except as shown in Figure 6-3(c), which is acceptable only where physical clearance is adequate for environment and electrical characteristics.

4. TOP ROUTE. Top route shall be connected as shown in Figure 6-4. Conductors which fill the gap between vertical posts shall be inserted to the depth of the shoulder. Conductors which do not fill the gap shall be accompanied by a tinned filler wire (solid or stranded) to help hold the conductor in position or shall be

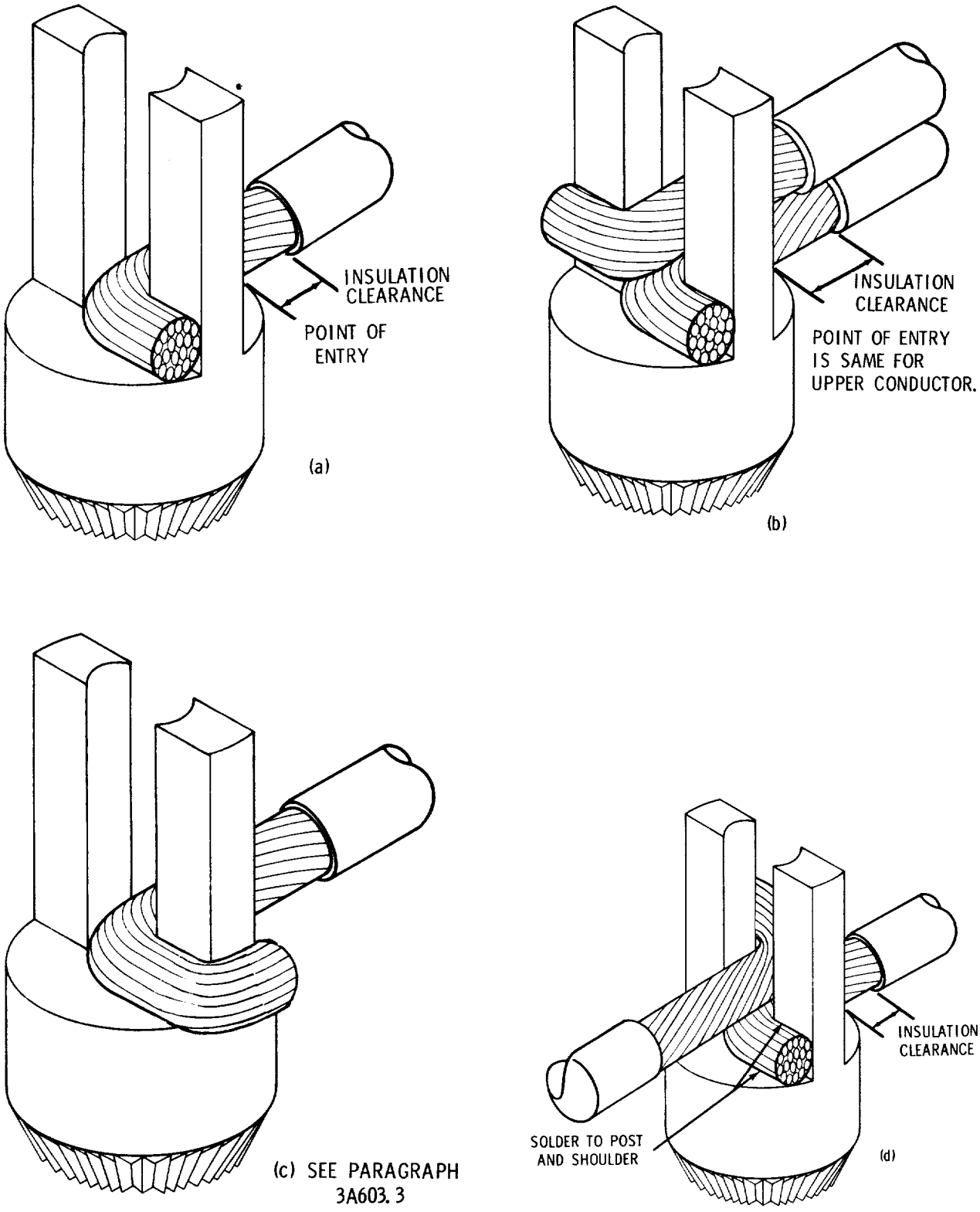


FIGURE 6-3--SIDE ROUTE CONNECTION TO BIFURCATED TERMINAL

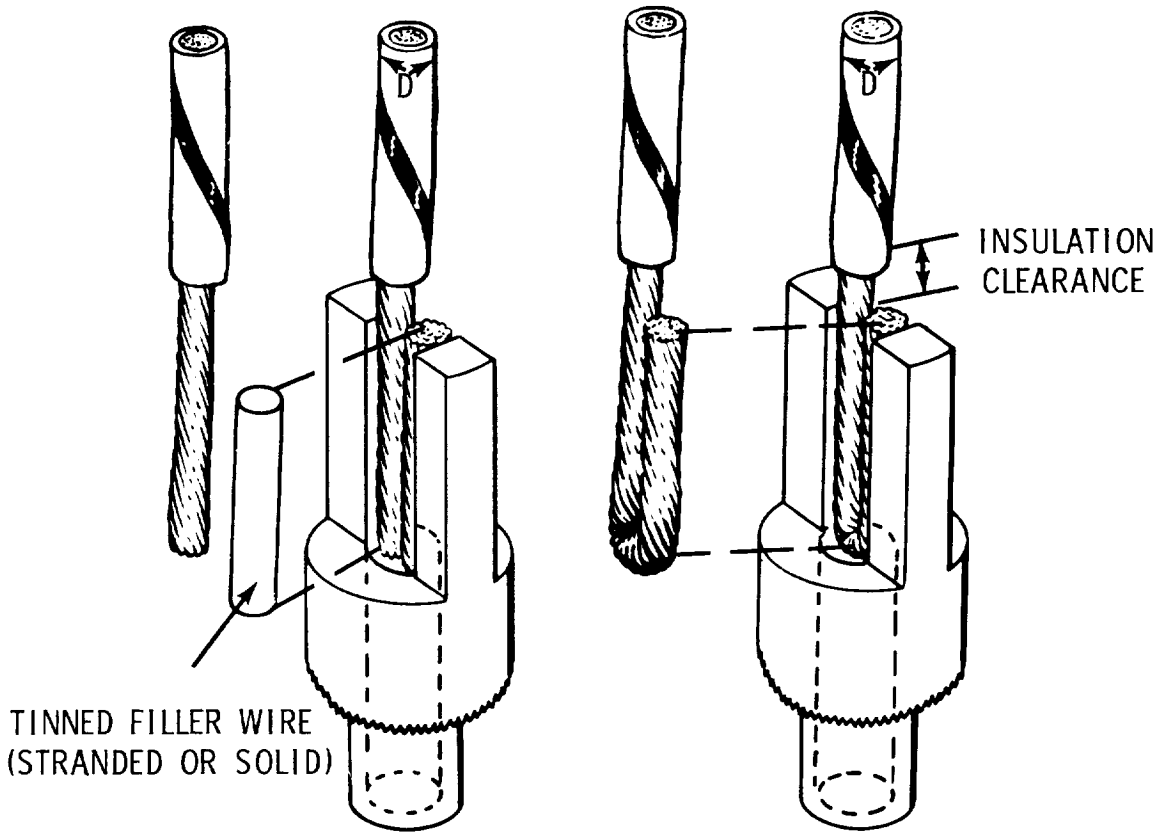


FIGURE 6-4--TOP ROUTE CONNECTION TO BIFURCATED TERMINAL

bent double as shown providing the combined diameters are sufficient to fill the gap. The top route and side route shall not be used on the same terminal. The top route shall not be used if there is sufficient room for side entry.

5. TOP AND BOTTOM ROUTE. The bottom route shall be installed first as shown in Figure 6-2, then the top route as shown in Figure 6-4 with the top route conductor bottoming on the bottom route conductor.

6. SIDE AND BOTTOM ROUTE. The bottom route shall be installed first as shown in Figure 6-2, then the side route as shown in Figure 6-3.

3A604 HOOK TERMINALS

Connections to hook terminals shall be as shown in Figure 6-5. The bend to attach conductors to hook terminals shall be a minimum of 1/4 turn to a maximum of 3/4 turn. Protrusion of conductor

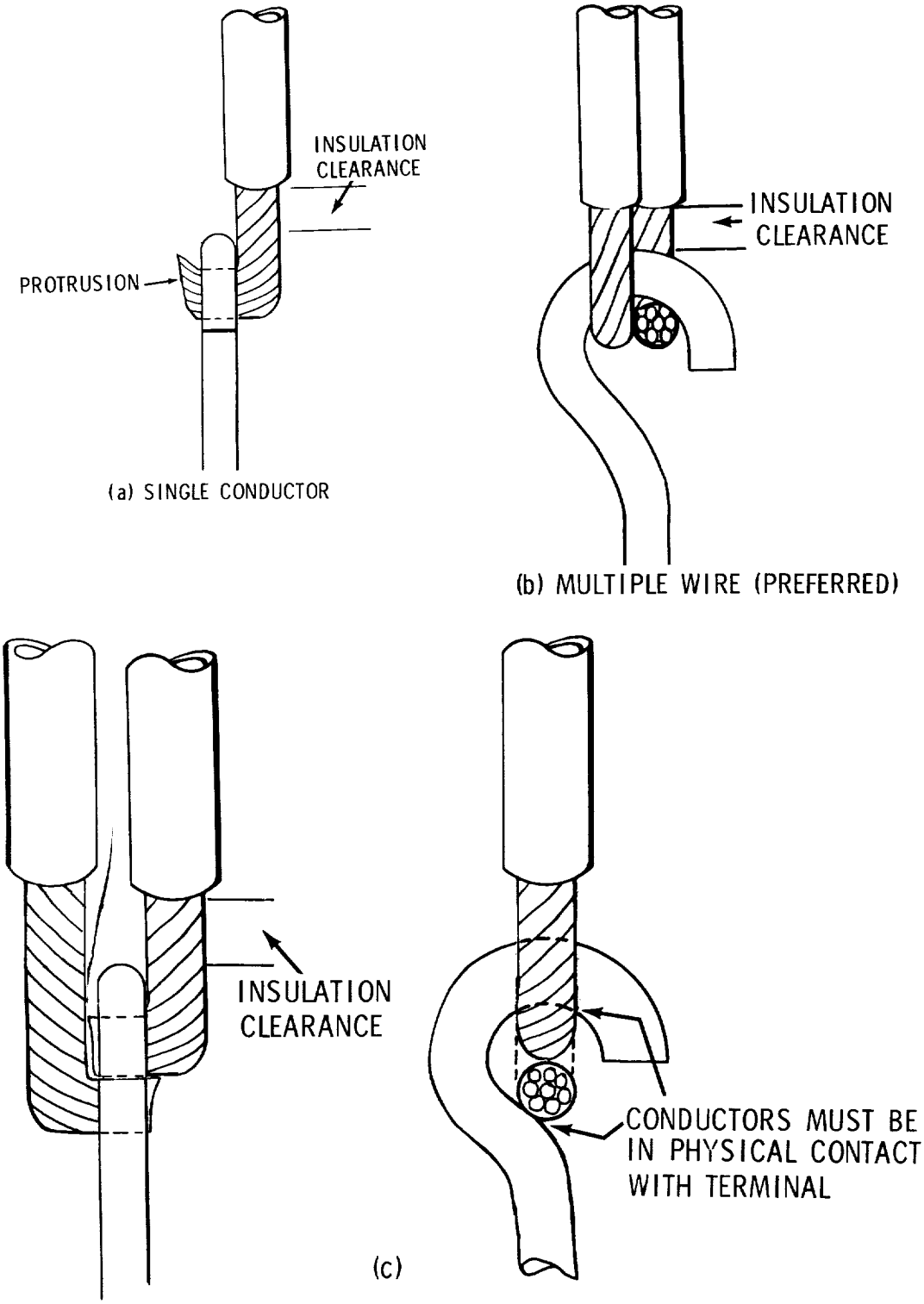


FIGURE 6-5--CONNECTIONS TO HOOK TERMINAL

ends shall be limited to avoid damage to insulation sleeving where used.

3A605 PIERCED TERMINALS

Connections to pierced terminals shall be as shown in Figure 6-6. The bend to attach conductors to pierced terminals shall be a minimum of 1/4 to a maximum of 3/4 turn. Protrusion of conductor ends shall be limited to avoid damage to insulation sleeving where used.

3A606 SOLDER CUPS (CONNECTOR TYPE)

Conductors shall enter the solder cup as shown in Figure 6-7. Conductors shall be bottomed in the cup and shall be in contact with the inner wall of the cup. The maximum number of conductors shall be limited to those which can be in contact with the full height of the inner wall of the cup.

3A607 SOLDER CUPS (SWAGED TYPE)

Connection shall be as shown in Figure 6-8. Conductors entering from the top shall be in contact with the inner wall of the cup and shall bottom in the cup or on the bottom conductor.

3A608 CONNECTION WITHOUT TERMINALS

When solid conductors are approved by NASA to be used as straight pin type terminals, conductors shall be terminated as specified in paragraph 3A602.

3A609 LAP JOINTS

A lap joint may be used for attaching conductors only where space does not allow room for bending the conductor, and the application has been reviewed by the procuring NASA Installation.

3A610 INSULATION TUBING APPLICATION

Insulation tubing shall be used for electrical insulation, as appropriate; for example, hook terminals and solder cups which are not protected by insulating grommets, potting or conformal coating.

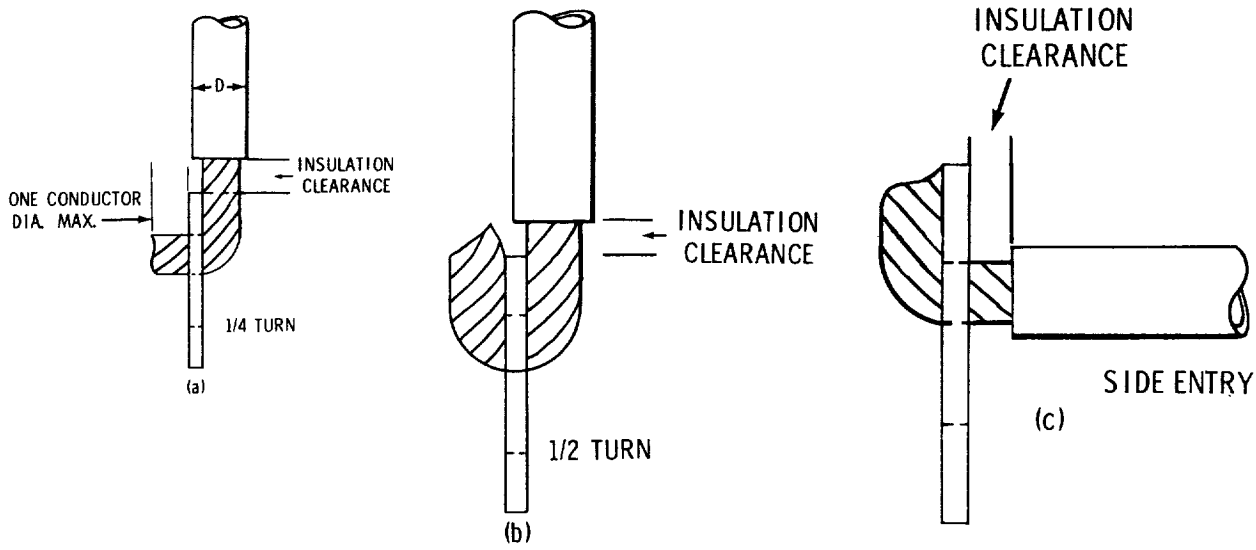


FIGURE 6-6--CONNECTIONS TO PIERCED TERMINALS

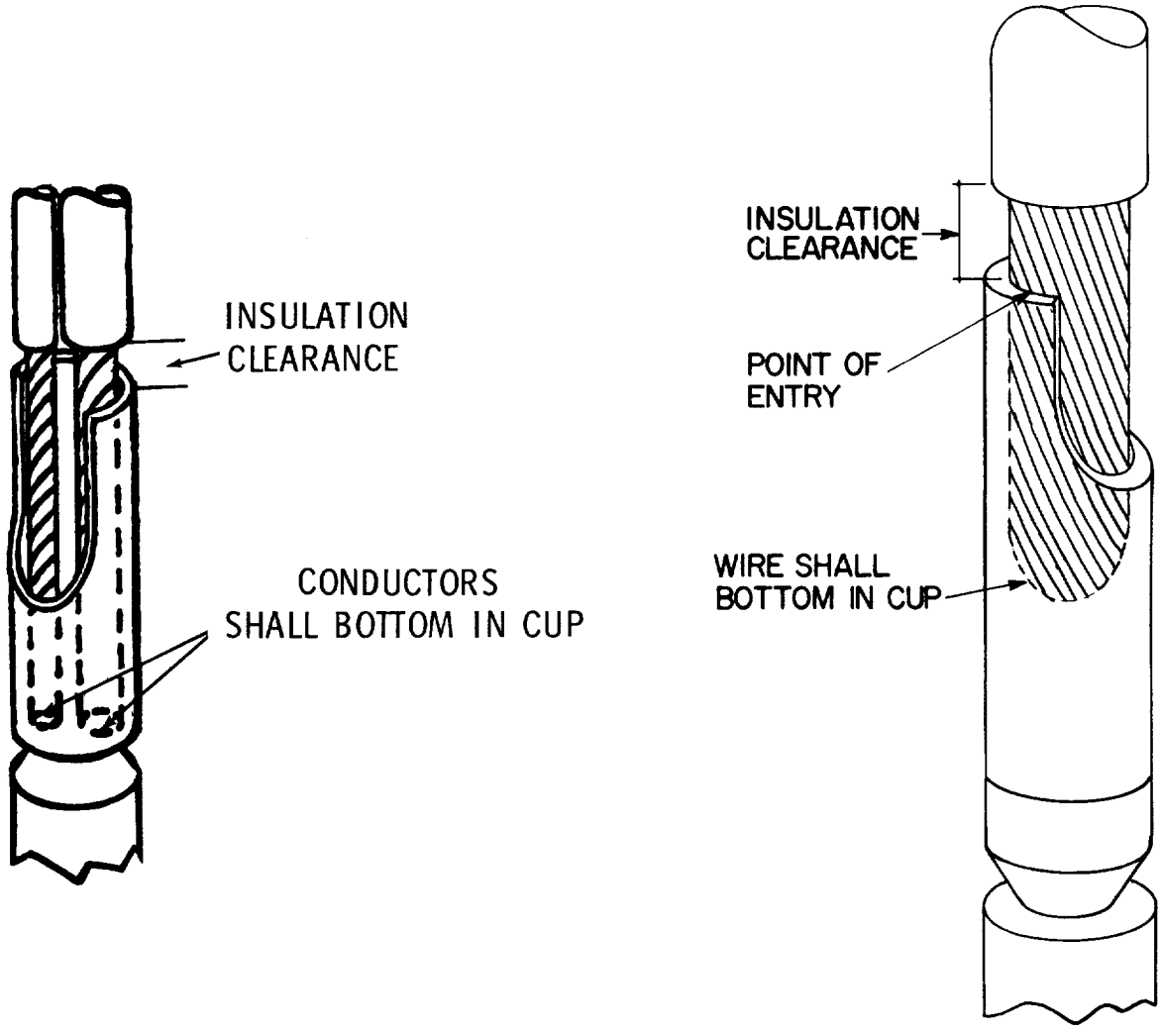
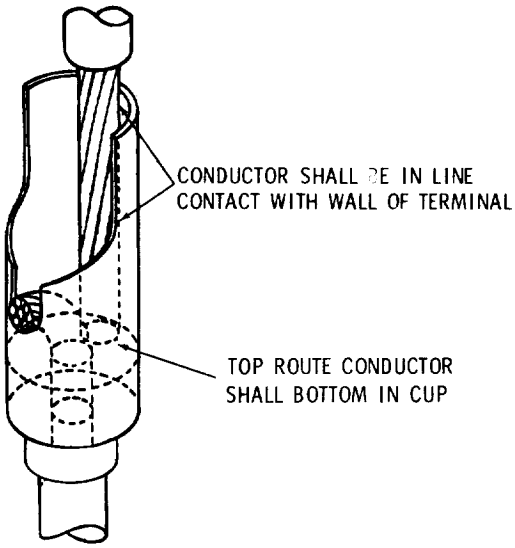
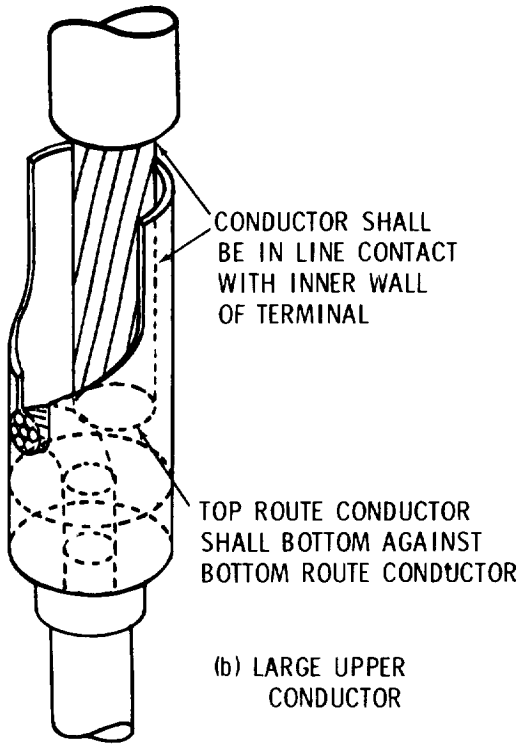


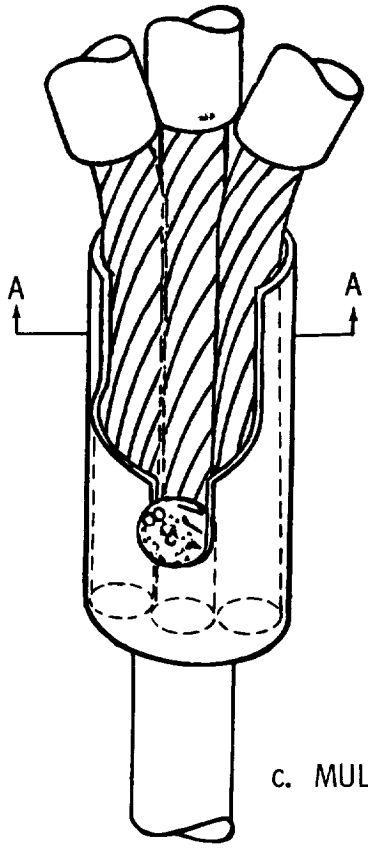
FIGURE 6-7--CONNECTIONS TO SOLDER CUPS (CONNECTOR TYPE)

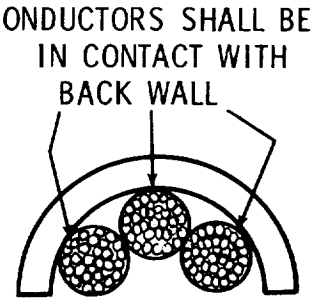


(a) SMALL UPPER CONDUCTOR



(b) LARGE UPPER CONDUCTOR





CROSS-SECTION VIEW A – A

c. MULTIPLE WIRES IN TOP ROUTE

FIGURE 6-8--CONNECTIONS TO SWAGED TYPE SOLDER CUPS

CHAPTER 7: SOLDERING OF TERMINALS

3A700 GENERAL

1. SECURING CONDUCTORS. There shall be no relative motion between conductors and the terminal during soldering and while the solder is solidifying.

2. INSULATION SLEEVING, POTTING OR COATING. Protective coverings or coatings on the soldered terminals shall comply with requirements of the contract or purchase order.

3A701 SOLDER APPLICATION

1. SWAGED TERMINALS. Terminals swaged to a solid flat conductor shall be soldered to one surface of the conductor.

2. ALL TERMINALS EXCEPT CUP

   a. A concave fillet of solder shall be formed between the terminal and each side of the conductor.

   b. The contour of the conductor shall be visible after soldering.

   c. Terminals with more than one wire shall have each wire in contact with and soldered to the terminal.

3. CUP TERMINALS

   a. The solder shall form a fillet between the conductor and the cup entry slot. The fillet shall follow the contour of the cup opening within the limits illustrated in the satisfactory solder connections, Appendix B.

   b. Solder spillage along the outside surface of the solder cup is permissible to the extent that it approximates tinning and does not interfere with the assembly or function of the connector.

4. WICKING. Flow of solder along the wire is permitted. Solder shall not obscure the contour of the conductor at the termination of the insulation.

3A702 REMOVAL OF FLUX AND RESIDUE

After the solder has solidified and cooled, flux and residue shall be carefully removed from each solder connection using a solvent as specified in paragraph 3A311.

3A703 INSPECTION

Each soldered connection shall be visually inspected in accordance with the criteria of this chapter. Magnification shall be as specified by the procuring NASA Installation. Parts and conductors shall not be physically disturbed to aid inspection. Illustrations of typical satisfactory and unsatisfactory soldered connections are shown in Appendix B.

3A704 ACCEPTANCE CRITERIA

An acceptable solder connection will be characterized by:

1. Clean, smooth, undisturbed surface.
2. Concave fillet between conductor and termination.
3. Contour of conductor visible.
4. Complete wetting.

3A705 REJECTION CRITERIA

The following are some characteristics of unsatisfactory solder conditions which are cause for rejection:

1. CONDUCTORS AND PARTS:
   a. Damaged, crushed, cracked, charred, melted, etc.
   b. Improper insulation clearance.
   c. Improper tinning.
   d. Separation of wire strands.
   e. Part improperly supported or positioned.
   f. Part marking not visible.
   g. Part damaged.
   h. Loose conductors.
   i. Cut, nicked, stretched or scraped leads or wires.
   j. Flux residue or other contamination.
   k. Improper wrap or stress relief.

2. SOLDER CONNECTIONS:

a. Cold joint.

b. Overheated joint.

c. Fractured joint.

d. Bare copper or base metal.

e. Improperly bonded joint.

f. Pitted or porous joint.

g. Excessive solder.

h. Insufficient solder.

i. Splattering of flux or solder or adjacent areas.

j. Rosin solder connection.

k. Unclean connection (e.g., lint, flux, dirt, etc.).

l. Dewetting.

CHAPTER 8: PRINTED WIRING ASSEMBLY SOLDERING

3A800 FABRICATION AND CONFORMAL COATING

Printed wiring boards shall be designed, fabricated, and inspected in accordance with the requirements of the contract or purchase order. The assembly of parts, soldering and inspection of the completed wiring assemblies shall be in accordance with the requirements herein.

3A801 GENERAL REQUIREMENTS

1. DIP SOLDERING. Manual dip soldering of printed wiring assemblies is not permitted.

2. PATTERN REPAIR. Repair of damaged or broken conductor patterns on printed wiring boards is not permitted.

3. MACHINE SOLDER REWORK. Rework of machine soldered printed wiring assemblies shall be performed in accordance with the soldering requirements of this publication.

4. GOLD REMOVAL. Gold plating shall be removed from the printed board areas to be soldered prior to mounting of parts. Removal shall not damage the copper conductor or add permanent contaminants to the insulating board. Boards shall be cleaned of contaminants before further processing.

5 EYELETS, TUBELETS AND PLATED-THROUGH HOLES. Eyelets or tubelets shall not be used as part of the electrical circuit on printed wiring boards. Plated-through holes shall not be used unaided as the electrical connection between conductor patterns on double-sided boards. A solid copper conductor, or a part lead, shall be used to make the interfacial electrical connection.

3A802 PRINTED WIRING BOARD PROTECTION

Printed wiring boards shall be protected to prevent damage or contamination during fabrication, inspection, in-plant transportation, and interim storage.

3A803 TERMINAL SOLDERING

Terminals swaged to conductor patterns shall be funnel swaged ("V" swaged) and soldered at all points of contact between the terminal and the conductor pattern. Roll type swaging shall not be used on the conductor pattern (see Figure 8-1). Terminals shall not be used for interfacial connection.

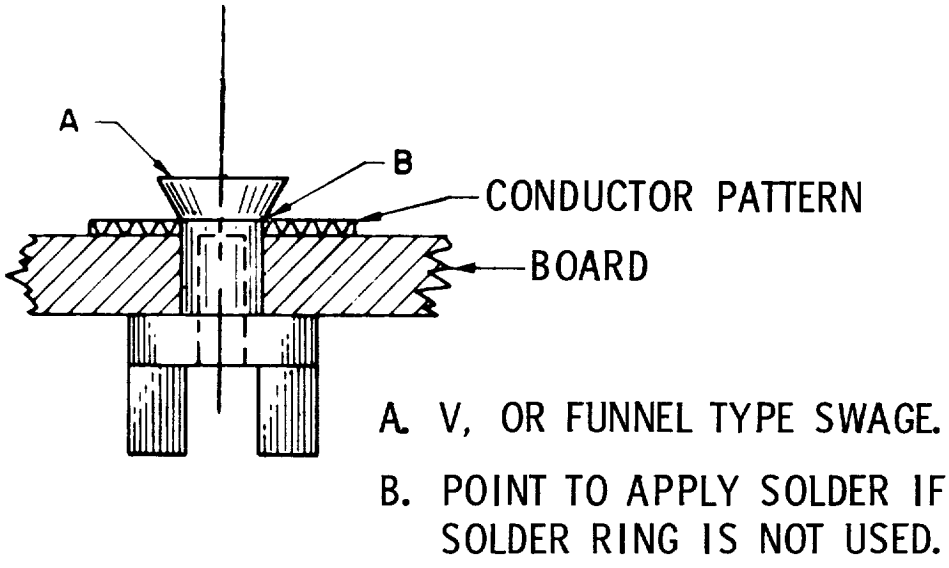


FIGURE 8-1--TYPICAL SWAGED TERMINAL ON PRINTED WIRING BOARD

3A804 PREPARATION AND SOLDERING OF TERMINATION AREAS

1. TERMINATION AREA. The termination area shall be clean prior to soldering. Soldering to printed wiring termination areas shall be to the base metal or to tin-lead coated base metal.

2. SOLDERING TO TERMINATION AREAS. The melted solder shall flow around the conductor and over the termination area so that a fillet is formed. The outline of the lead shall be visible in the finished connection. After soldering, flux residue and other contaminants shall be removed.

3A805 INSPECTION

Each completed printed wiring assembly shall be visually inspected to the criteria listed in paragraphs 3A806 and 3A807 and for other indications of poor workmanship or nonconformance to the design drawings. Magnification shall be as specified by the procuring NASA Installation.

3A806 ACCEPTANCE CRITERIA

The following are characteristics of acceptable solder connections to printed wiring assemblies:

1. Clean, smooth, undisturbed surface.

2. Regular, even fillet between conductor and termination area.

3. Contour of conductor visible.

4. Complete wetting.

3A807 REJECTION CRITERIA

The following are some characteristics of unsatisfactory printed wiring assemblies which are cause for rejection:

1. Charred, burned, or melted insulation or parts.
2. Conductor pattern separation from board.
3. Burns on base materials.
4. Discoloration which is continuous between conductors (e.g., measling, delamination, halo effect, etc.)
5. Excessive solder (including peaks, icicles, and bridging).
6. Flux residue, solder splatter, or other foreign matter.
7. Dewetting.
8. Insufficient solder (a small amount of exposed base metal around the periphery of the termination area or at the end of a conductor is acceptable if conformal coating will be applied).
9. Pits, holes or voids, or exposed base metal in the soldered connection.
10. Cold, rosin, disturbed, or fractured solder connection.
11. Cut, nicked, gouged, or scraped conductors or conductor pattern.
12. Improper conductor length or direction of clinch.
13. Repaired or damaged conductor pattern.

CHAPTER 9: AUTOMATIC MACHINE SOLDERING

3A900 GENERAL

This chapter contains requirements peculiar to automatic machine soldering. General requirements including acceptance and rejection criteria specified in this publication are applicable.

3A901 DOCUMENTATION

1. The supplier shall estabish complete and detailed documentation for operation and maintenance of the soldering machines and their environment, and for inspection of both the process and the end-products.

2. The documentation shall set limits on the:

   a. Preheat temperature,

   b. Temperature of the solder,

   c. Conveyor speed,

   d. Height of the solder wave,

   e. Control of the dross inhibition oil and flux (if fluxing is done as a machine step),

   f. Amount of contaminants permissible when the solder bath is analyzed,

   g. Frequency of maintenance and of analysis and other factors affecting the quality of the connections in the end-product,

   Maintenance and calibration data shall be recorded and available to Government and supplier inspection.

3A902 PREPARATION AND ASSEMBLY

1. Only tin-lead (solder) coated and reflowed electro-plated tin-lead coated conductor patterns shall be used in machine soldering of printed wiring board assemblies.

2. Parts shall be mounted as specified in Chapters 5 and 6 of this document. The mounting shall prevent relative motion between part and board during solder solidification.

3. The assembled boards shall be clean immediately prior to loading on to the carrier.

4. Metal surfaces not to be soldered shall be masked or coated with a solder resist prior to loading.

5. Liquid flux specified in paragraph 3A310 shall be applied.

3A903 MACHINE REQUIREMENTS

1. The preheat temperature shall be controlled to a selected temperature between 160° and 180° F. The selected temperature shall be maintained within ± 5° F.

2. The conveyer speed shall be controlled to a preselected rate, which shall not vary more than 1 inch per minute.

3. Solder temperature shall be controlled so that the solder in the wave making contact with the board is 490° F ± 10° F.

4. The oil used as a dross inhibitor shall have a flash point higher than the maximum solder temperature.

5. The height of the solder wave shall be controlled to a constant preselected height.

6. The solder bath shall be chemically analyzed periodically for conformance with the requirements of paragraph 3A309 except that copper content shall not exceed 0.2%.

3A904 CLEANING

After soldering, flux and dross inhibitor oil shall be promptly removed in a manner which does not damage the hardware.

3A905 INSPECTION

Inspection criteria listed in Chapter 8 are applicable to machine soldered assemblies. Warp or twist of the board shall not exceed the limits specified by the detail drawing.

DEFINITIONS

The following definitions apply to terms used in this Handbook.

Article. A unit of hardware or any portion thereof required by the contract.

Bifurcated (split) Terminal. A terminal containing a slot or split in which wires or leads are placed before soldering.

Certification. The act of competent authority in verifying and documenting that personnel have completed required training and have demonstrated specified proficiency and have met other specified requirements.

Cold Solder Connection. Unsatisfactory connection resulting from dewetting and exhibiting an abrupt rise of the solder from the surface being soldered.

Conduction Soldering. Method of soldering which employs a soldering iron for transfer of heat to the soldering area.

Conductor. A lead or wire, solid or stranded, serving as an electrical connection between terminals.

Conformal Coating. A thin protective coating which conforms to the configuration of the covered assembly.

Cordwood Construction. Circuitry in which parts are mounted between, and perpendicular to, two printed wiring or conductive networks.

Deviation. A specific authorization, granted before the fact, to depart from a particular requirement of specifications or related documents.

Dewetting. The condition in a soldered area in which the liquid solder has not adhered intimately, characterized by an abrupt boundary between solder and conductor, or solder and terminal/termination area.

Disturbed Solder Connection. Unsatisfactory connection resulting from relative motion between the conductor and termination during solidification of the solder.

Electrical Connection. Connections in electrical or electronic circuits.

Excessive Solder Connection. Unsatisfactory connection wherein the solder obscures the configuration of the connection.

Eyelet. A tubular metal part having both ends headed or rolled over.

Fractured Joint. A solder joint in which the solder has fractured or broken between the joint elements.

Hook Terminal. A terminal formed in a hook shape.

Mission Essential Support Equipment. Mission-essential support equipment is defined as satisfying any of the following:

1. Equipment used in a closed loop with the system where failure would degrade the mission or imperil personnel.

2. Equipment used when transferring toxic or explosive fluids, in which failure could result in personnel hazards or affect mission success.

3. Equipment used as a last check prior to installation whose failure would result in lowering the probability of mission success or compromising personnel safety.

Part Lead. The wire, solid or stranded, which extends from and serves as a connection to a part.

Part. One piece, or two or more pieces joined together which are not normally subject to disassembly without destruction of designed use. Synonomous with detail part and component part (e.g. resistor, capacitator, valve, relay).

Potting Compound. A nonconductive compound used for encapsulation of parts, conductors or assemblies.

Pierced (Perforated) Terminal. A terminal containing a hole through which leads or wires are placed before soldering.

Pits. Small holes or sharp depressions in the surface of the solder.

Repair. Operations performed on a nonconforming article to place it in useable and acceptable condition. Repair is distinguished from rework.

Resistance Soldering. Method of soldering, by passing a current between two electrodes through the area to be soldered.

Rework. The reprocessing of articles or material that will make it conform to drawings, specification or contract.

Rosin Solder Connection. Unsatisfactory connection which has trapped flux.

Overheated Joint. An unsatisfactory solder joint, characterized by rough solder surface.

Solder. A nonferrous, fusible metallic alloy used when melted to join metallic surfaces.

Solder Cup Terminal. A hollow, cylindrical terminal to accommodate one or more conductors.

Soldering. The process of joining metallic surfaces through the use of solder without direct fusion of the base metals.

Straight Pin Terminal. A round post-type smooth terminal, with no grooves, slots, or guides.

Supplier. A contractor or subcontractor actually performing the services or producing the contract articles.

Terminal. A tie point device used for making electrical connections.

Termination. The point at which an electrical conductor ends, usually at an electrical connection.

Termination Area. A conductive surface on a printed wiring board used for making electrical connections. (Also referred to as printed circuit pad).

Thermal Shunt. A device with good heat dissipation characteristics used to conduct heat away from an article being soldered.

Tinning. The coating of a surface with a uniform layer of solder, before it is used in a soldered connection.

Tubelet. A tubular metal part with both ends formed in a conical flare of approximately 90 degrees included angle.

Turret Terminal. A round post-type grooved stud around which conductors are fastened before soldering.

Waiver. Granted use, or acceptance, of an article which does not meet specified requirements.

Wetting. Adhesion of a liquid to a solid surface.

Wicking. The flow of molten solder by capillary action.

TYPICAL SATISFACTORY AND UNSATISFACTORY SOLDER CONNECTIONS

The Illustrations in this Appendix depict typical satisfactory and unsatisfactory solder connections and are to be used as visual workmanship standards. See paragraphs 3A703, 3A805 and 3A905.

FIGURE B-1--SOLDERED TURRET TERMINALS

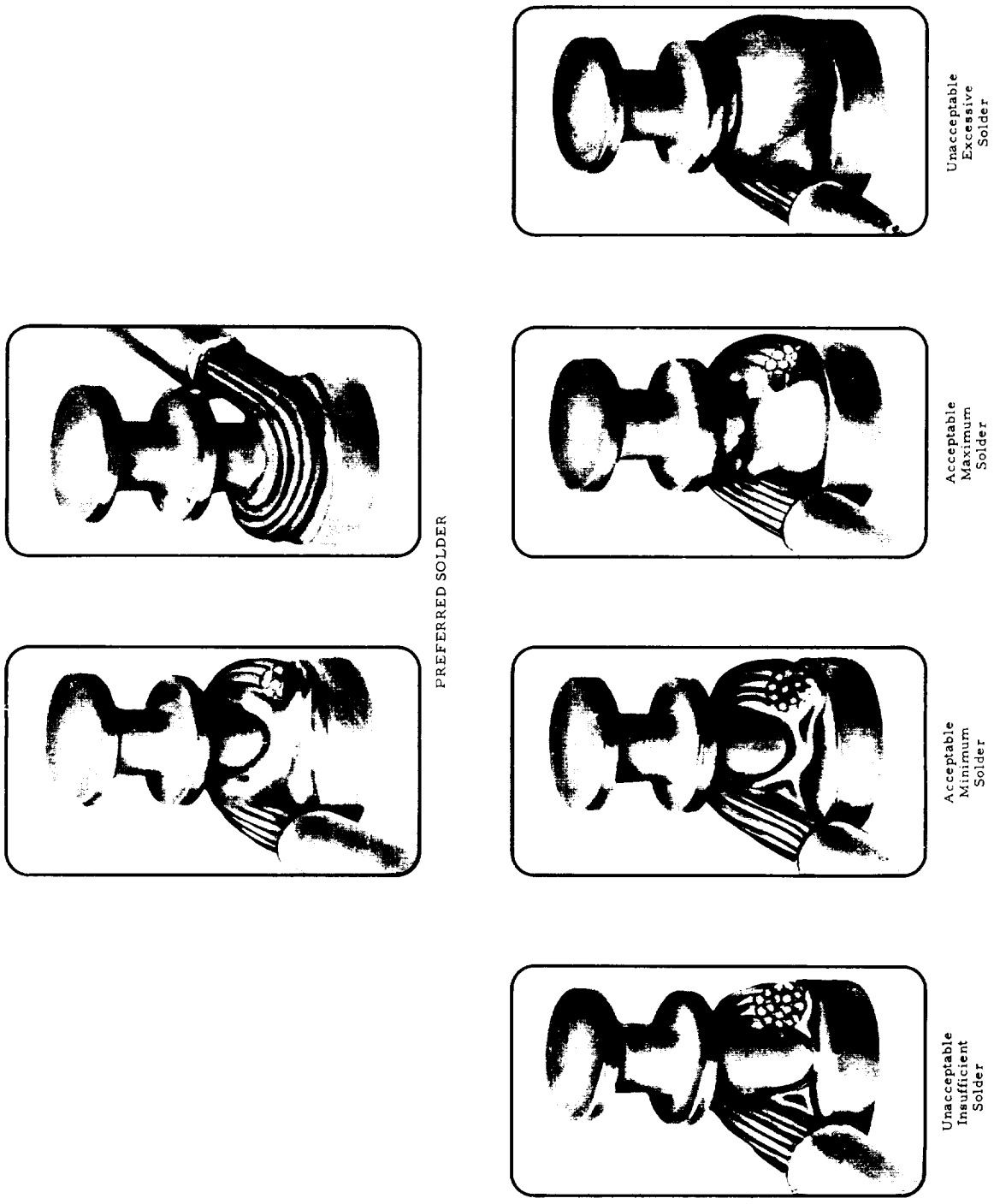


FIGURE B-1--SOLDERED TURRET TERMINALS--Con.

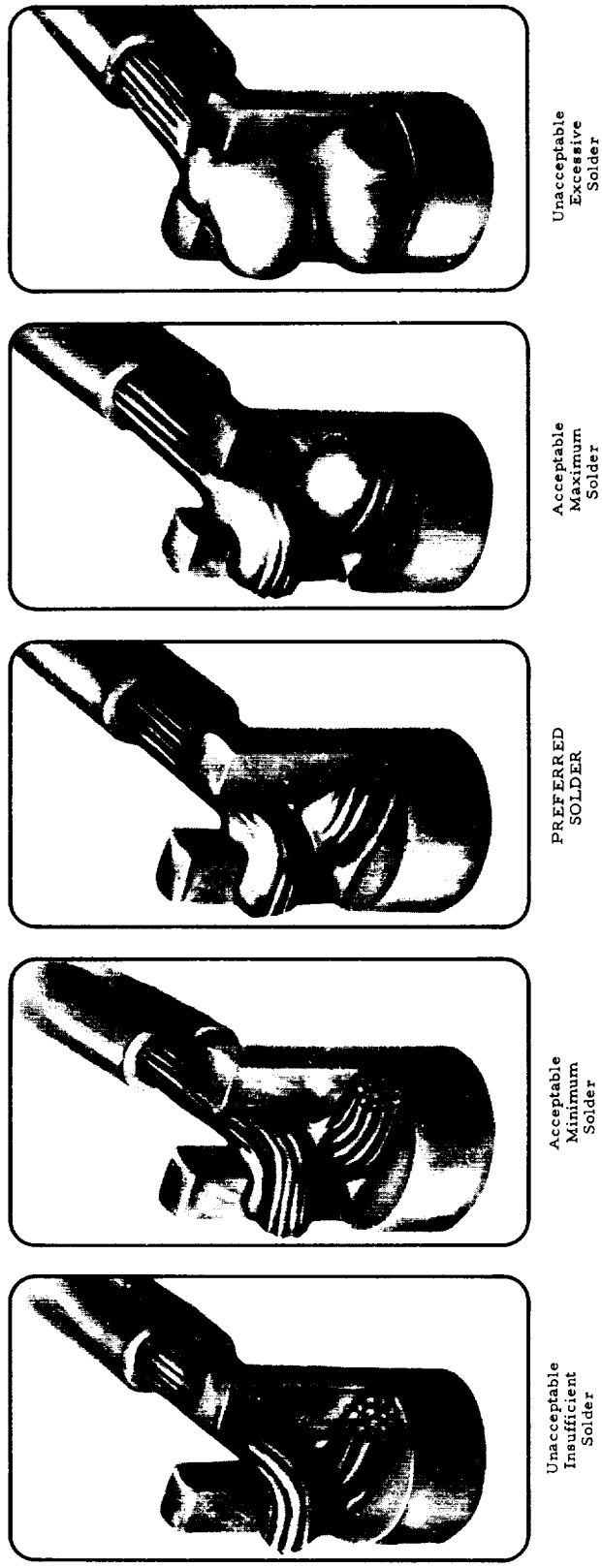


FIGURE B-2--SOLDERED BIFURCATED TERMINALS

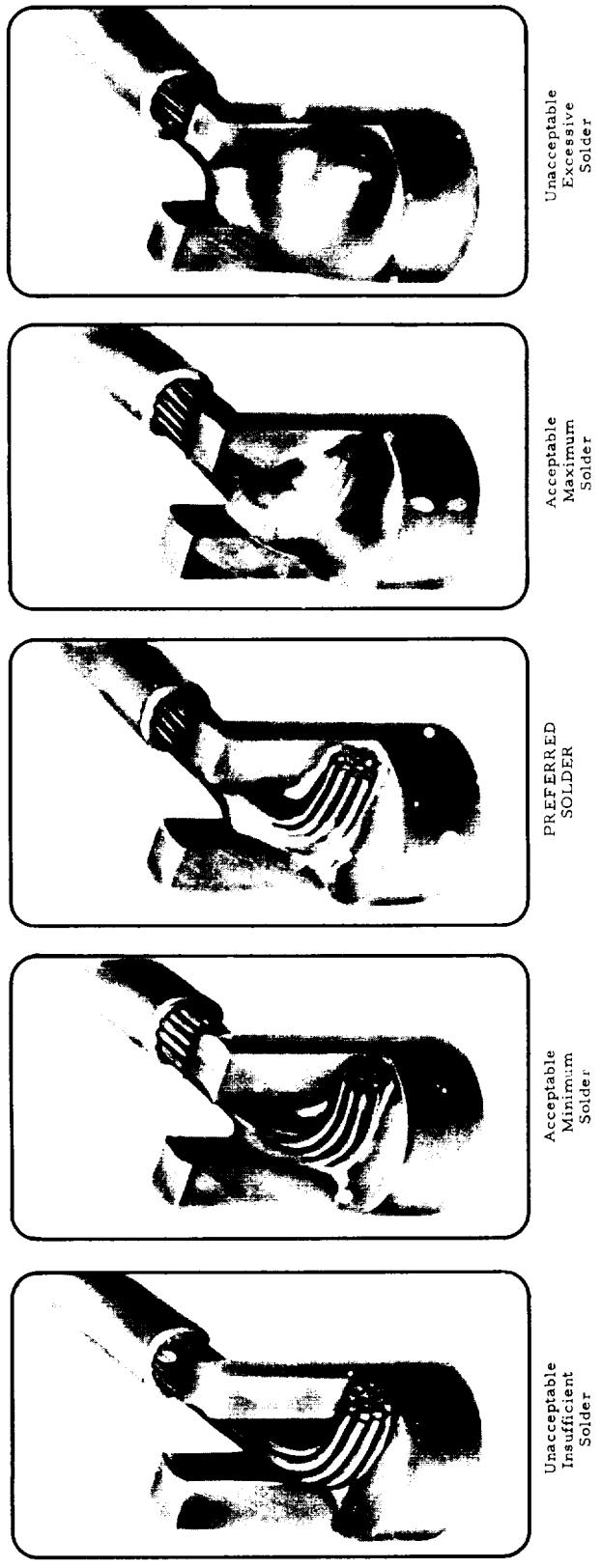


FIGURE B-2--SOLDERED BIFURCATED TERMINALS--Con.

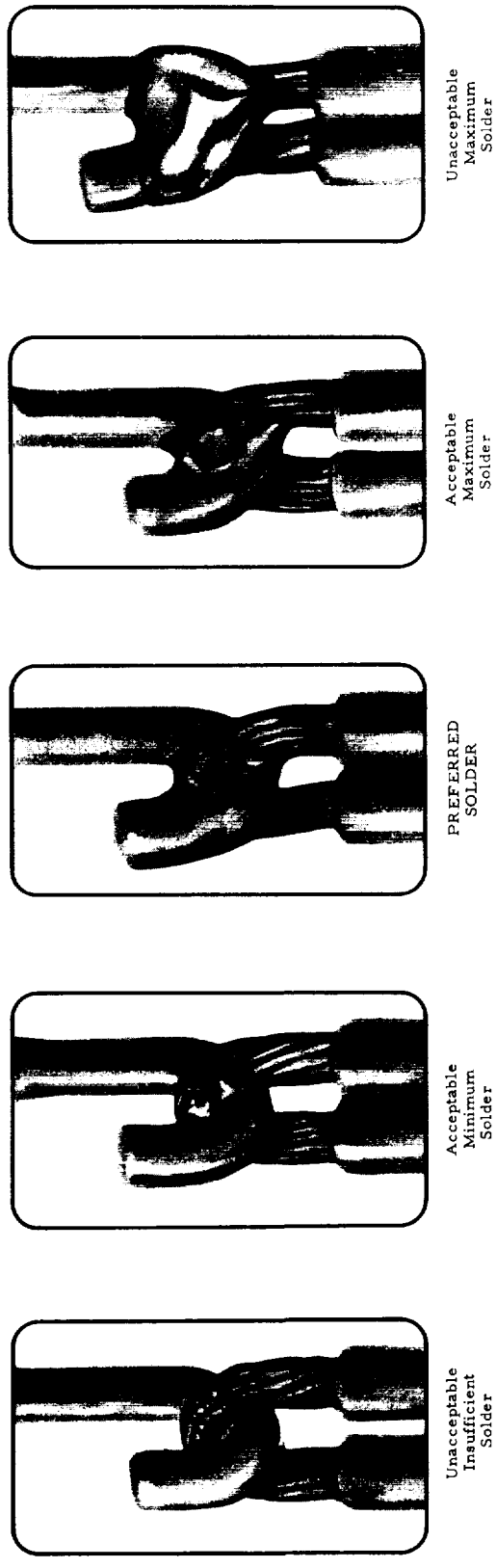


FIGURE B-3--SOLDERED HOOK TERMINALS

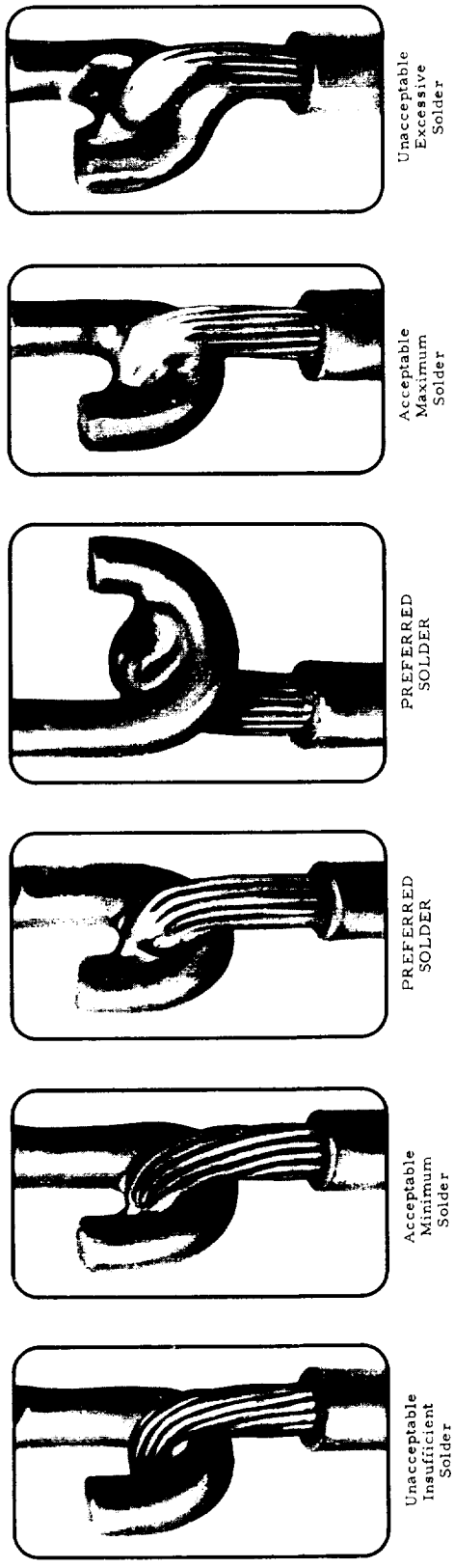


FIGURE B-3--SOLDERED HOOK TERMINALS--Con.

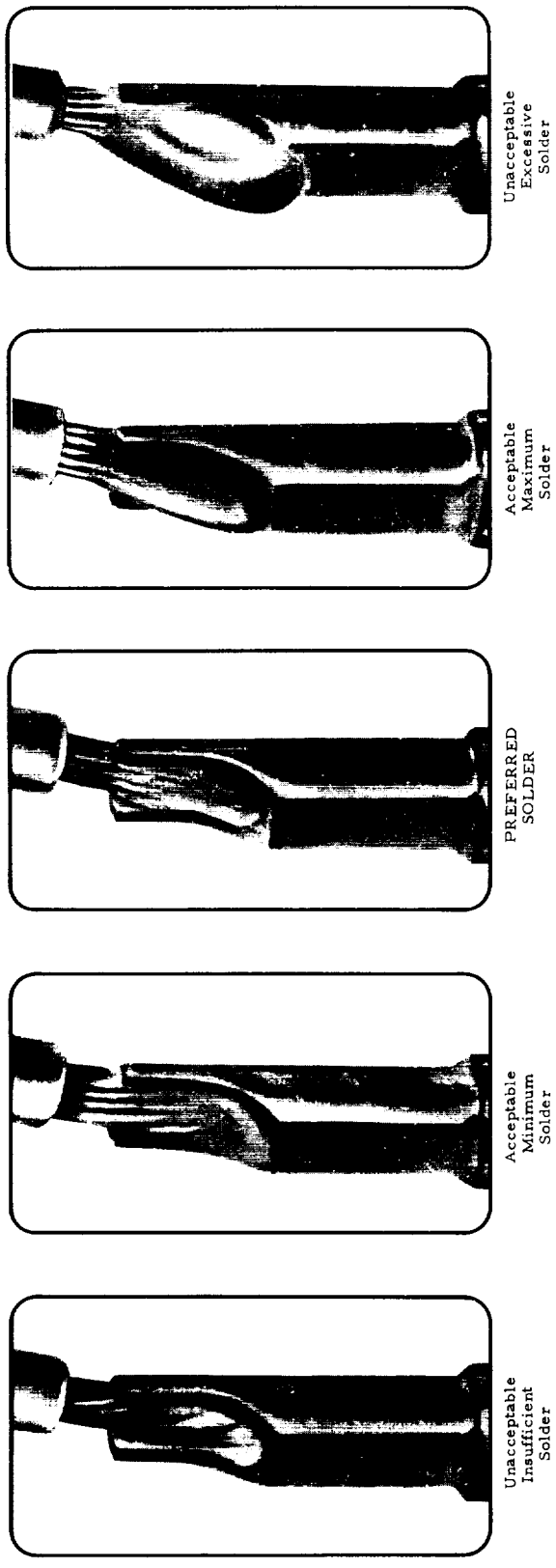


FIGURE B-4--SOLDERED CUP TERMINALS

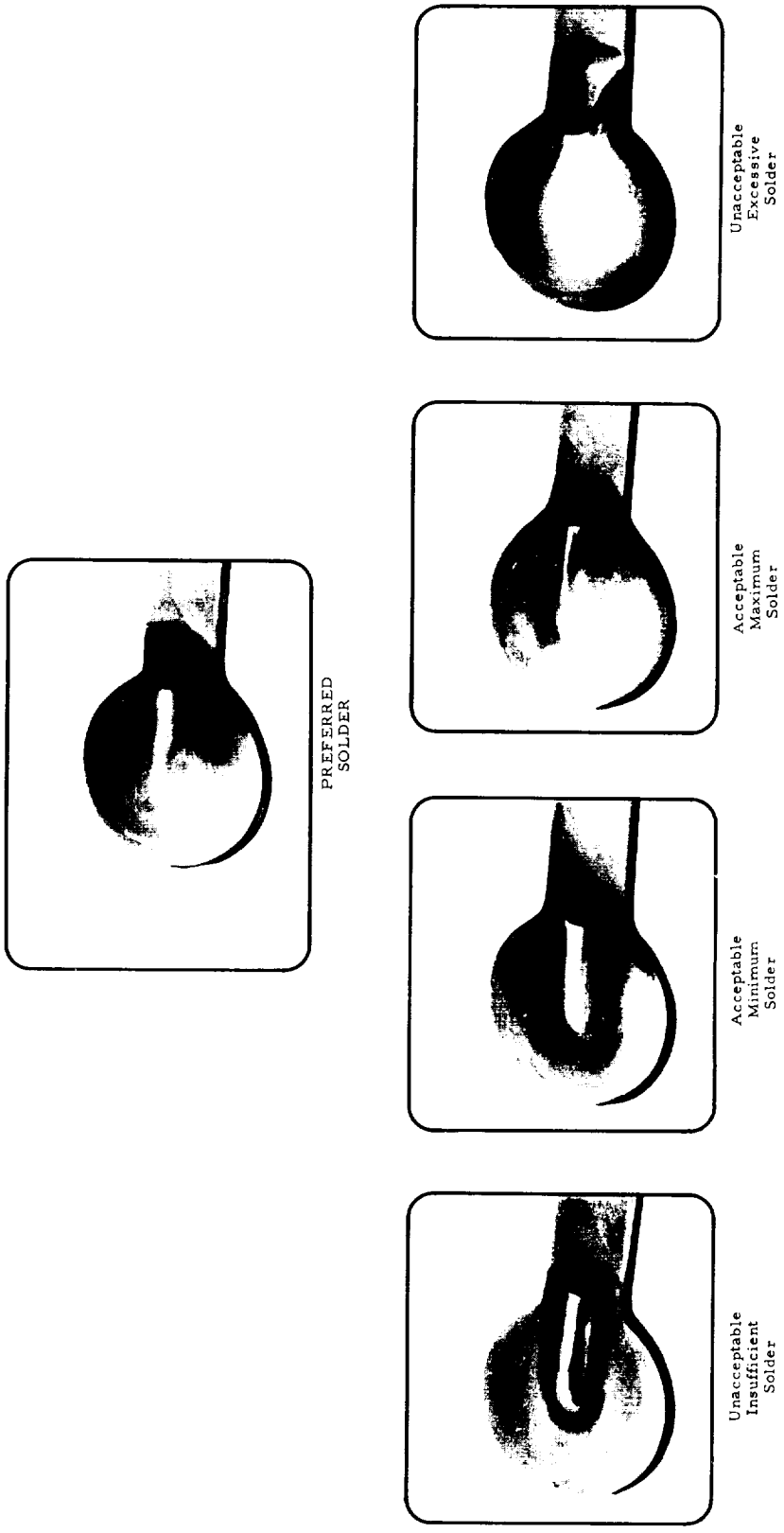


FIGURE B-5--SOLDERED PRINTED WIRING AREAS

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